DESIGN OF CABLE STAYED BRIDGE USING STADD PRO SOFTWARE

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Abstract : The information collected during this study discusses the design of a cable stayed bridge. Design of this type of bridge using with the help of Finite Element Method becomes easier. STAAD pro software uses the FEM. FEM helps to compute technique used to obtain approximate solution of boundary values problems in engineering. The cable-stayed bridge is useful where cantilever bridges and suspension bridges cannot be useful. This is the range within which cantilever bridges would rapidly grow heavier, and suspension bridge cabling would be more costly.

Keywords:- Bridge Engineering, Design, Finite Element Method, Finite Element Analysis, Cable stayed bridge, suspension bridge, Steel girders, cables, pylons, pier, tension and compression.

I. INTRODUCTION

Cable-stayed bridges may appear to be similar to suspension bridges, but in fact, they are different in principle and in their structural type.

A CABLE STAYED BRIDGE has one or more towers from which cables support the bridge deck. The cables which run directly from the tower to the deck, normally forming a fan-like pattern or a series of parallel lines. This is in contrast to the modern suspension bridge where the cables supporting the deck are suspended vertically from the main cable, anchored at both ends of the bridge and running between the towers.

In cable-stayed bridges, the towers are the primary load-bearing structures that transmit the bridge loads to the ground. A cantilever approach is often used to support the bridge deck near the towers, but lengths further from them are supported by cables running directly to the towers. That has the disadvantage, unlike for the suspension bridge, that the cables pull to the sides as opposed to directly up, which requires the bridge deck to be stronger to resist the resulting horizontal compression loads, but it has the advantage of not requiring firm anchorages to resist the horizontal pull of the main cables of the suspension bridge. By design, all static horizontal forces of the cable-stayed bridge are balanced so that the supporting towers do not tend to tilt or slide and so must only resist horizontal forces from the live loads.

The following are key advantages of the cable-stayed form:

- much greater stiffness than the suspension bridge, so that deformations of the deck under live loads are reduced
- can be constructed by cantilevering out from the tower – the cables act both as temporary and permanent supports to the bridge deck
- for a symmetrical bridge (in which the spans on either side of the tower are the same), the horizontal forces balance and large ground anchorages are not required.

Connections of stay cables to a pylon can be anchored to the pylon. When a stay cable is cradled through the pylon, the cable is continuous from the deck on one side of the pylon to the deck on another.

In a cable-stayed bridge, the cross section of the main girder can be a multiple-cell box, two I-section girders, or trusses. Concrete box girders are widely used in short span ranges.

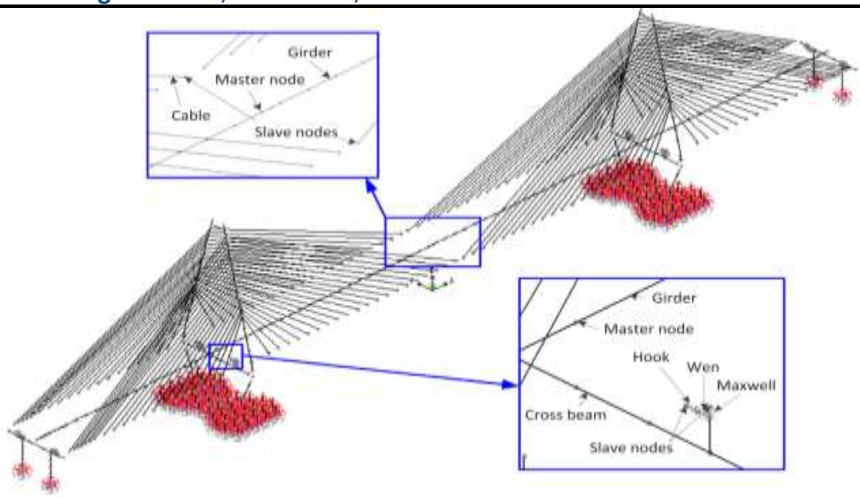


Fig.1 – Elements of cable stayed bridge

II. DESIGN OF STRUCTURE

Previously bridges were designed by art rather than by means of science or engineering. By having limited knowledge of structural behavior, bridges were designed. But now by the progression of technologies, computer software and hardware, material properties, theory of structures, advanced structural members, bridge design becomes more science than art.

Before invention of cement, concrete and steel materials, bridges were built with the help of wood, stone and clay with shorter span length. After invention of mortar material and arch type structures, Roman's started building strong and light weight bridges and viaducts. In 18th century, material like CI, enabled creation of new bridges types such as truss type bridges.

Later invention of computer and computational tools, bridge design was extended up to incredible span length.

Now a days concrete and steel are the main materials for bridges as it can form different shapes and structural types.

MAJOR CHARACTERISTICS OF CABLE STAYED BRIDGE

1. The deck acts as a continuous beam with no. of elastic supports with varying stiffness.

2. Deck and pylon are both in compression and therefore bending moment in these elements will be increased, due to second order effects. Application of these moments will be non-linear.

3. The use of influence lines, which rely on the principle of linear superposition, can only be used as an approximate method of determining the stay loads.

4. Non linear material properties (creep and shrinkage) will also influence the design.

Basically, design process includes the stages given below

1. Determine the back span to main span ratio.
2. Determine cable spacing.
3. Determine deck stiffness.
4. Determine pylon height.
5. Determine preliminary cable force.
6. Deck form i.e. (concrete / composite / hybrid)
7. Deck design
8. Deck erection
9. Static analysis
10. Dynamic analysis

1. Back span to main span ratio

Ratio between back span and main span should be less than 0.5. It influences the uplift forces at the anchor pier and the range of load within the back stay cable supporting the top of pylon.

Desired length of back span will be between 0.4-0.45 of the main span.

2. Cable spacing

Spacing of stay anchors or tendons along the deck should be compatible with the capacity of longitudinal girders and the limiting stay’s size.

Spacing should be small enough so that deck may be erected using cantilevering method.

3. Deck stiffness

Deflection of longitudinal girder is primarily determined by stay layout

Depth of girders should be kept minimum, subject to sufficient area and stiffness being provided to carry the large compressive forces without bending.

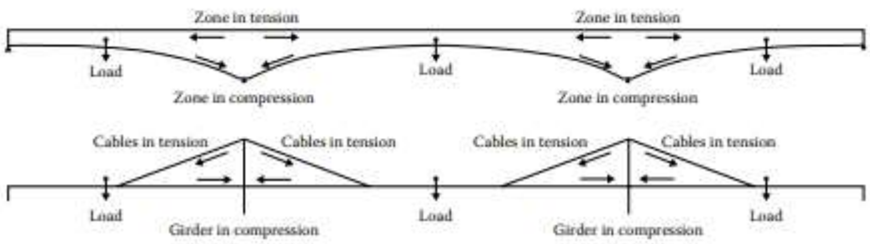


Figure 11.1 From reinforced to cable-stayed bridge.

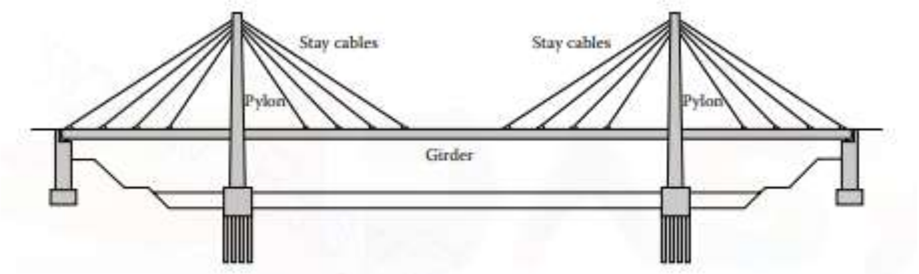


Fig. 2 – Type of member under loading.

4. Pylon height

The height of pylon will determine overall stiffness of structure. As the stay angle increases, the required stay size will decrease as will the height of pylon. However deflection of deck will increase as each stay becomes longer.

Most efficient stay is the one having inclination angle at 45^{o}.

This will keep the optimum ratio of pylon height above the deck to main span is between 0.2-0.25.

5. Preliminary stay forces

The main stay forces resist the dead loads such that there is no deflection of the deck or pylon.

An initial approximation of main span stay forces can be determined by considering structure as a simple truss ignoring bending stiffness of both the pylon and deck, ignoring bending stiffness of the pylon will be a valid assumption as the bending stiffness of pylon is usually small when compared to axial stiffness of stays.

The back stay anchoring forces can be determined assuming the horizontal component of main span and back span stay forces are balanced at pylon.

6. Deck form

Primary factors influencing the choice of deck will be the length of main span and deck width.

Concrete deck section is most economic for span range 200 – 400m and composite deck above 400m.

Above 600m a hybrid combination is economic with the back span as concrete and the main span in all steel construction.

7. Deck design

It is possible to minimize the moments in deck under the dead load by tuning the loads in stays to the small local moments arising from the span between stays.

The balance between positive and negative live load moments at any section along the girder will not be equal.

In most cases the properties of deck section will be more favorable when resisting moments.

8. Deck erection

Common method for deck erection is cantilever method.

The stay forces that are compatible with final distribution of dead load moment and the defined structure geometry are known. However the initial stay forces introduced at each stage of erection are not.

Backward stage analysis :- completed structure is dismantled stage by stage.

Forward stage analysis.

9. Static analysis

For final analysis, most common approach is to model either a half or entire structure as a space frame.

Pylon, deck and stays will usually be represented within space frame model by truss elements.

Stays can be represented with a small inertia and a modified modulus of elasticity that will mimic the sag behavior of stays.

10. Dynamic analysis

Seismic analysis of structure

Response of structure to turbulent wind

Time history transient analysis of vibrations.

Aim of study

- The aim is to study and analyse the various design classes of cable stayed bridges like mono, harp, fan and star.
- This study includes various arrangements of support columns, discussed later.
- To study applications of cable stayed bridge for railway, pedestrian or roadways
- To Study the design and behaviour of cable stayed bridges with help of research papers and under the guidance of guide.

Objectives of the study

- To discuss various challenges occurring while design of cable stayed bridge and encounter it. Also studying the seismic and [1]dynamic responses of cable stayed bridge.

III. BASIC DESIGN DATA

LENGTH OF BACK SPAN – 60 METERS

LENGTH OF MAIN SPAN – 130 METERS

LENGTH OF BACK SPAN ON OTHER END – 60 METERS

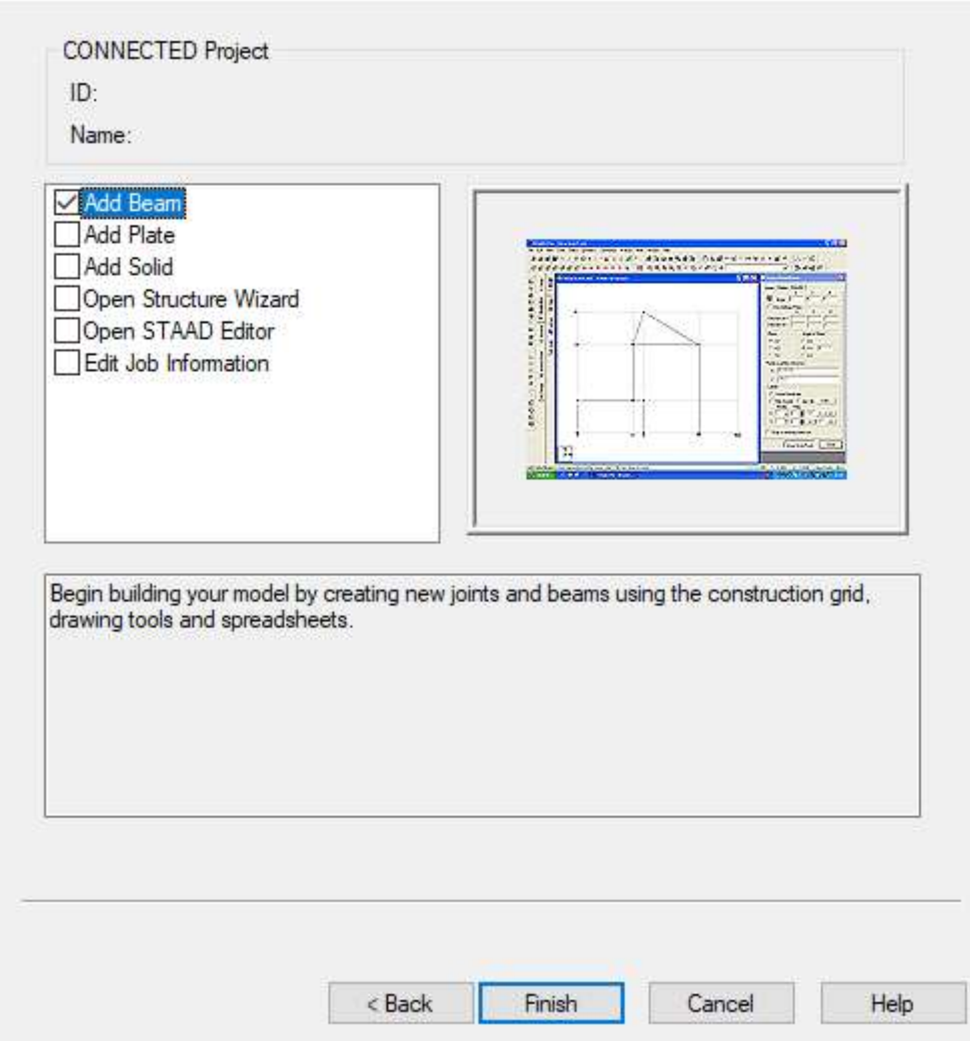
LENGTH OF CARRIAGEWAY – 20 METERS

TOTAL LENGTH OF STRUCTURE – 250 METERS

We will discuss step by step procedure for the design of cable stayed bridge by using STAAD pro software.

At first we have to choose which member of the structure we are going to design. i.e. space, plane, floor or truss. By choosing the member, we have to select the length and force units.

Select the member we are designing first.



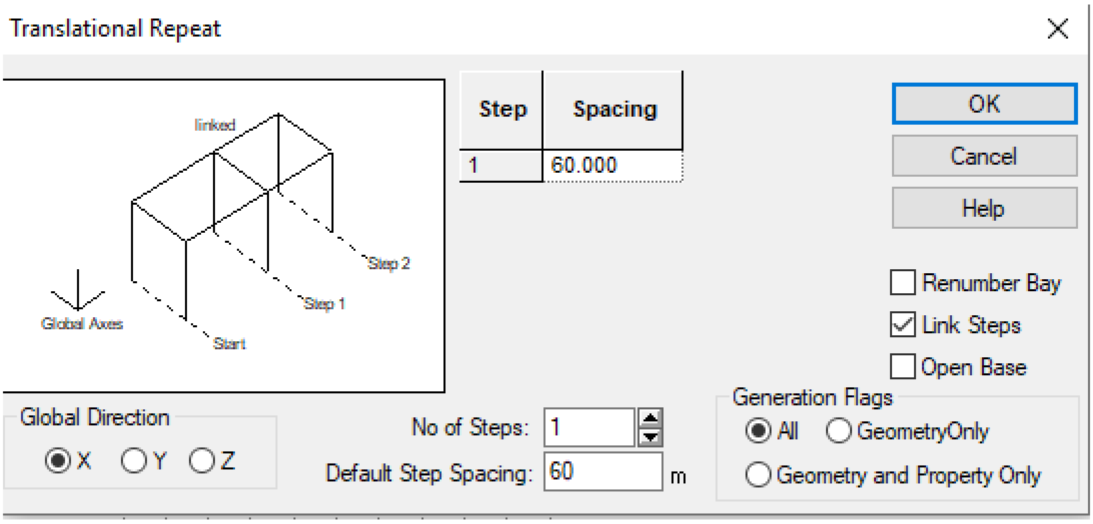
Selecting one node anywhere on mesh, first point of structure may start. By choosing translational repeat command, take the next node at required length and the required axis. For our design of bridge, we are taking it on 60 meters. And in the X-axis.

Break up for 250 meters will be as follows.

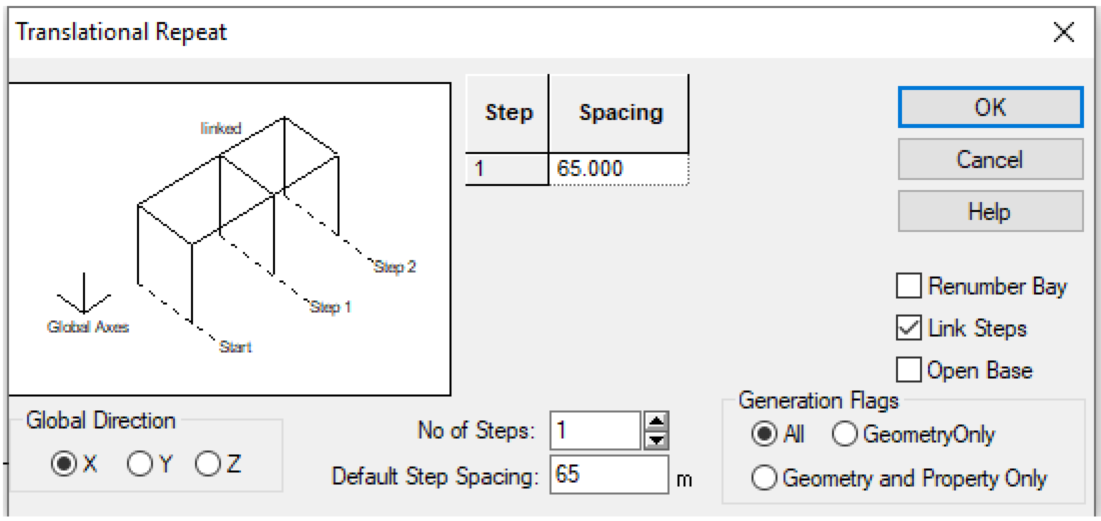
Back span will be of 60 meters. Main span will be of 110 meters. Again back span on the other end will be of 60 meters.

Design ratio of back span to the main span is almost 45-50% of the main span.

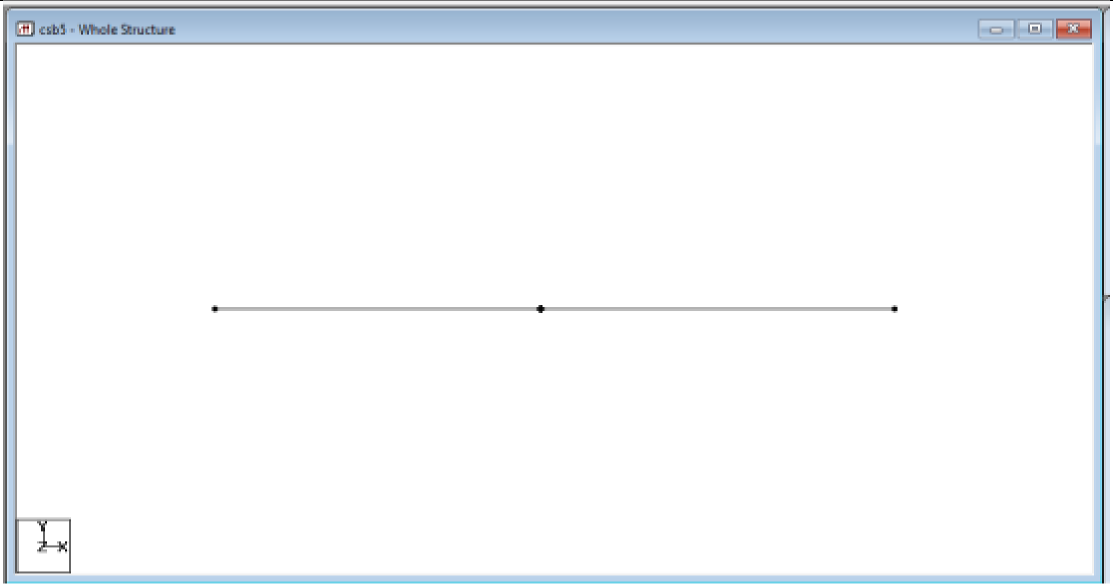
Hence it is okay.



For the main span of 130 meters, and for using mirror command, we are taking another node on the half of the length of the main span i.e. 65 meters. Link steps is for connecting the two nodes.



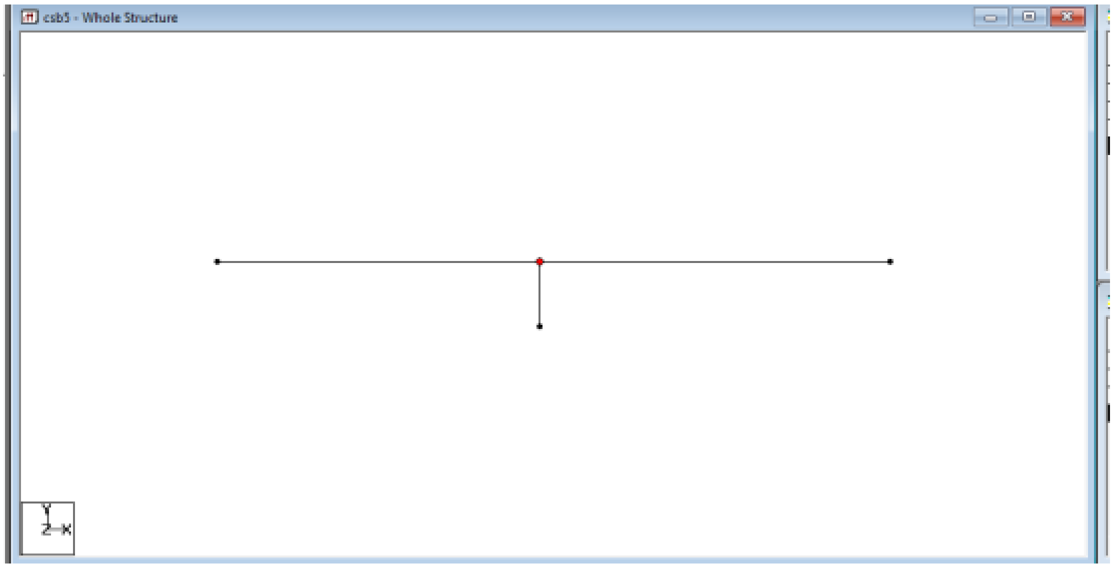
By linking steps, 3 nodes were connected with 2 beams of 60 and 65 meters.



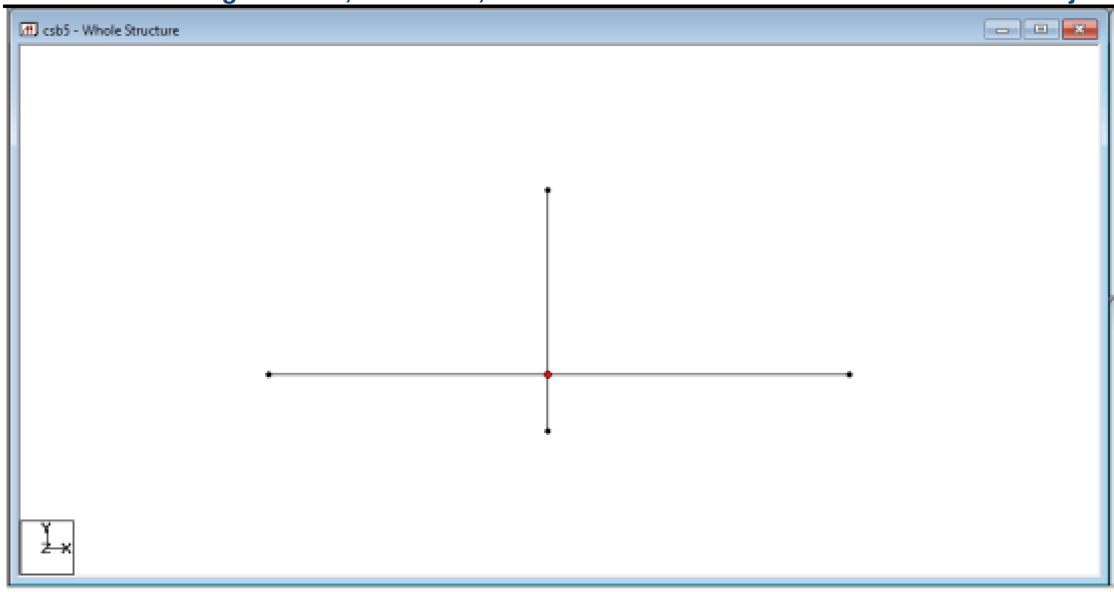
For the pier support of the structure, considering it at depth of 12 meters.

As it is downwards it can be taken as negative.

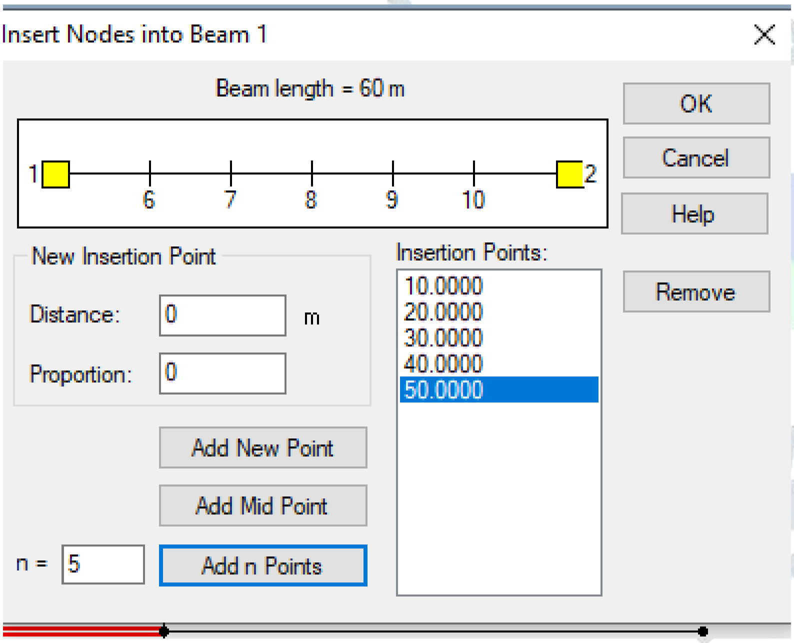
Span will look like this.

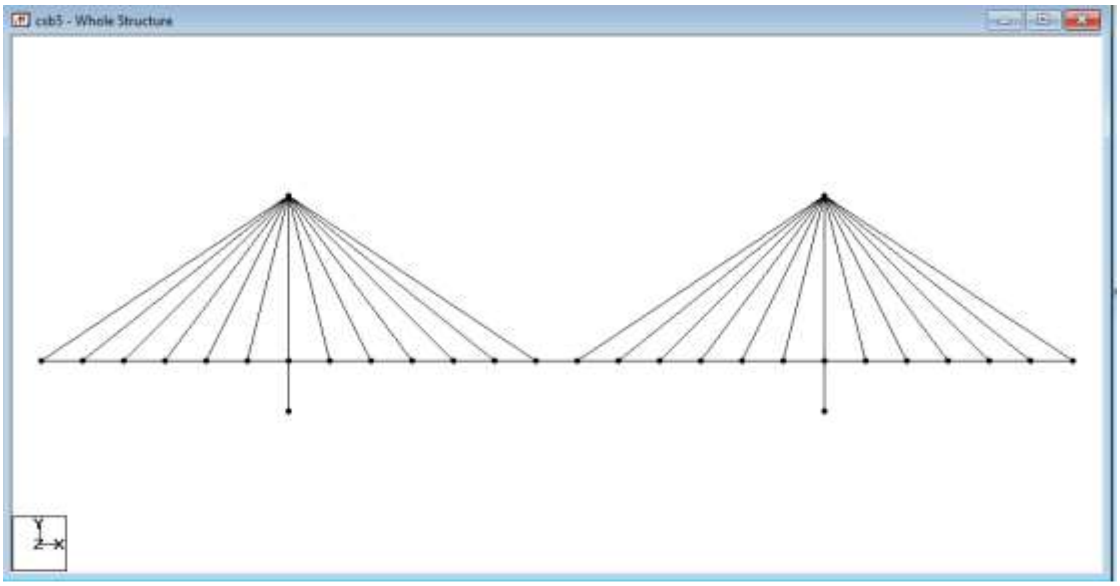


Considering vertical support called as ‘tower’ of height 40 meters.



For the back span, first beam member may split into 5 equal parts. And the nodes were created. Here, n= number of partitions required or splitting the member into number of nodes. Then click on “Add n points” and then ok.





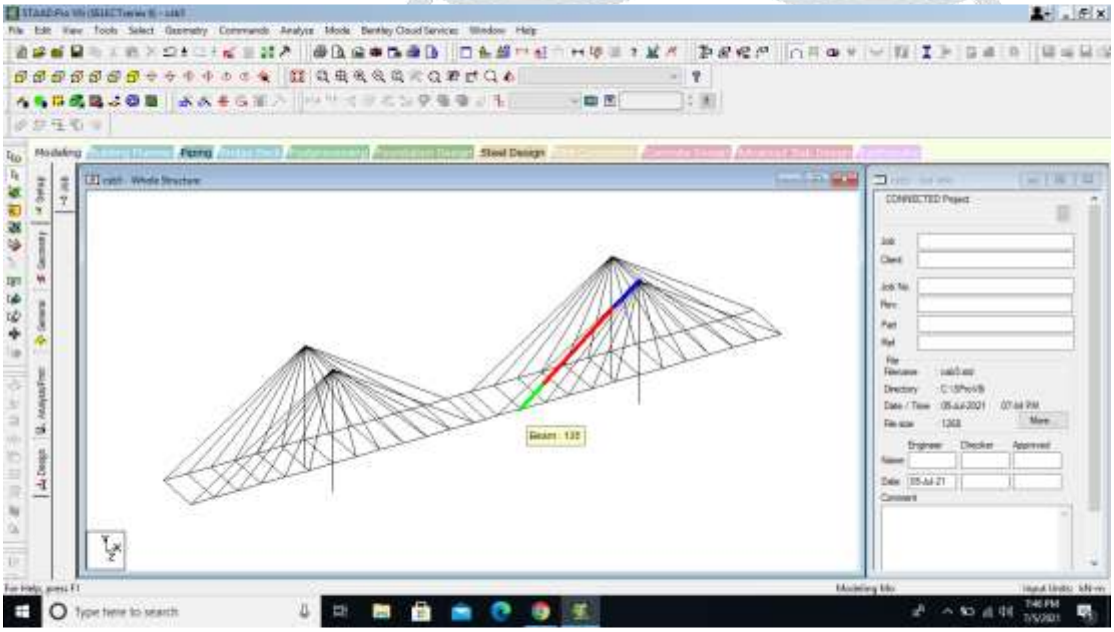
By using translational repeat command, carriageway of bridge is taken at 20 meters as for two way traffic, 20 meters as per IRC (Indian Road Congress)

IRC-2- 1983: DIMENSIONS AND WEIGHT OF ROAD DESIGN VEHICLES

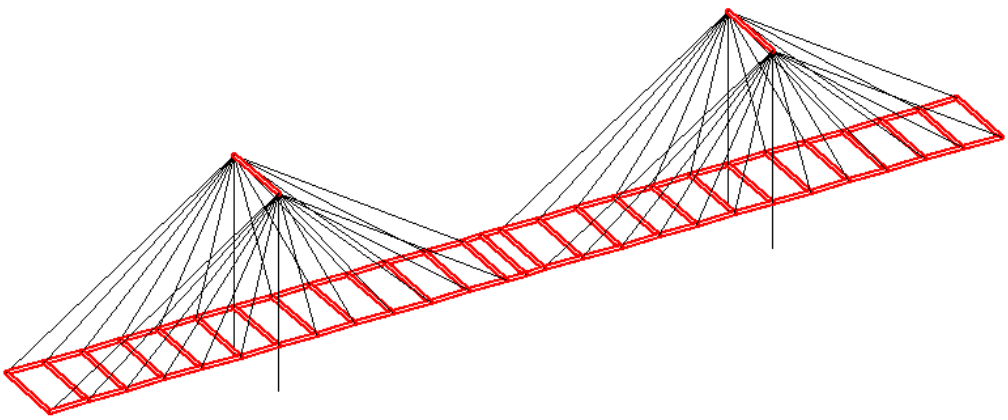
IRC-5- 2005: STANDARD SPECIFICATIONS AND CODE OF PRACTICE FOR ROAD BRIDGES

IRC-7- 2007: RECOMMENDED PRACTICE FOR NUMBERING CULVERTS, BRIDGES AND TUNNELS

IRC-24- 2001: STANDARD SPECIFICATIONS CODE OF PRACTICE FOR ROAD BRIDGES.



Model will look like this.



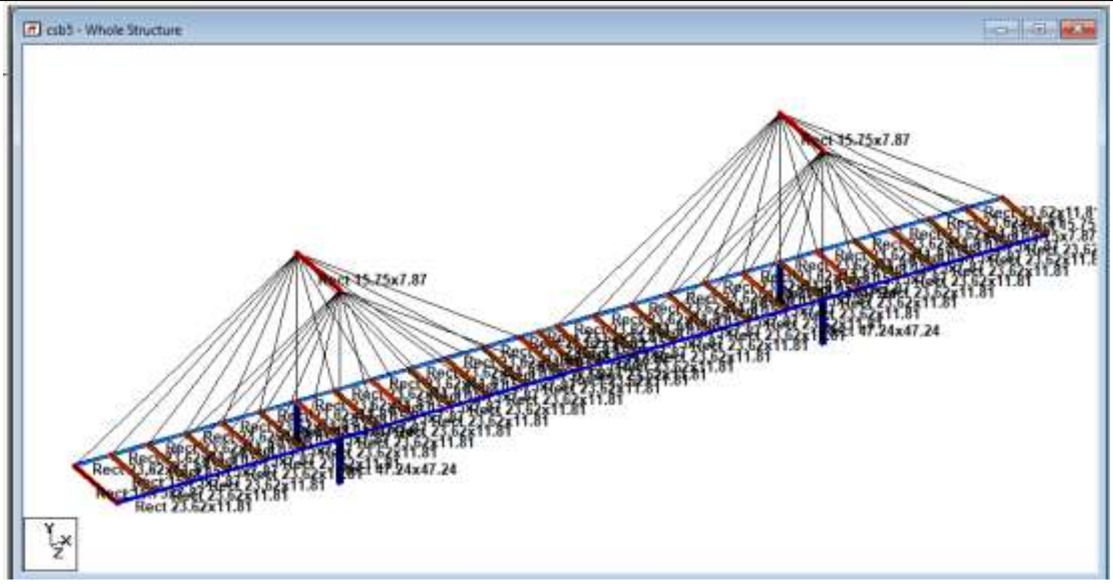
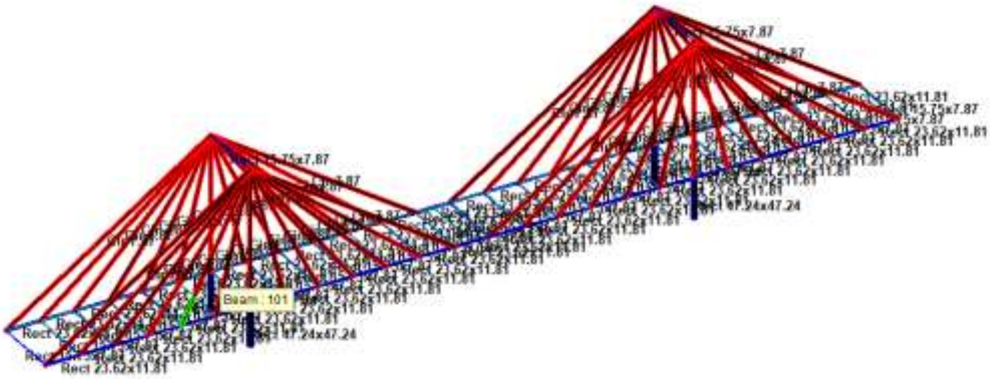


Fig 3 – Material properties of structure



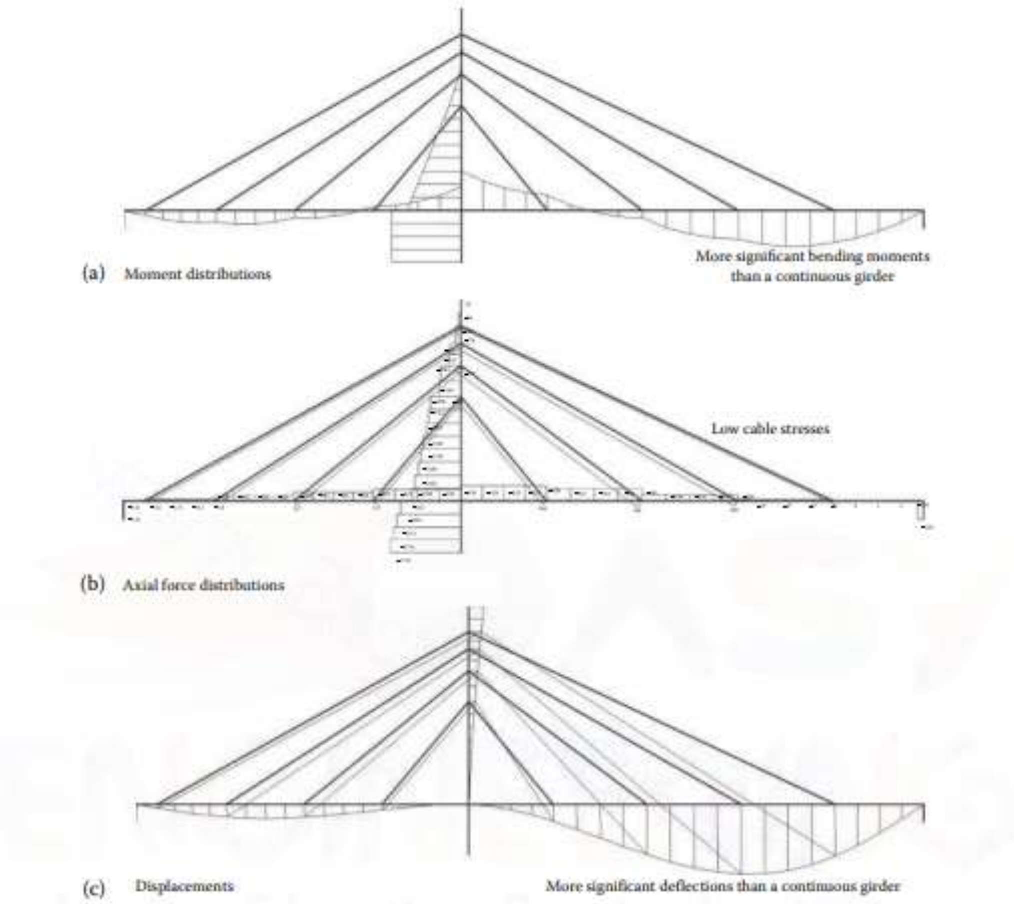


Fig 4 - Bending moment and axial force deformation in cable stayed bridge as follows after giving loading conditions.

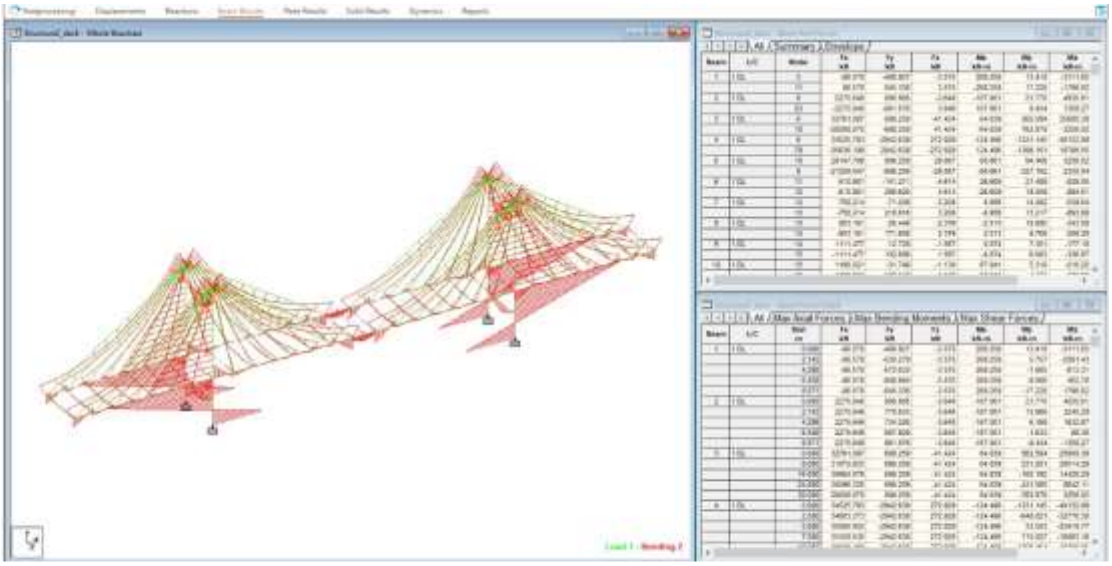


Fig 5 - Maximum axial forces, bending moments and shear forces developed after giving loading condition on our structure in X, Y and Z direction.

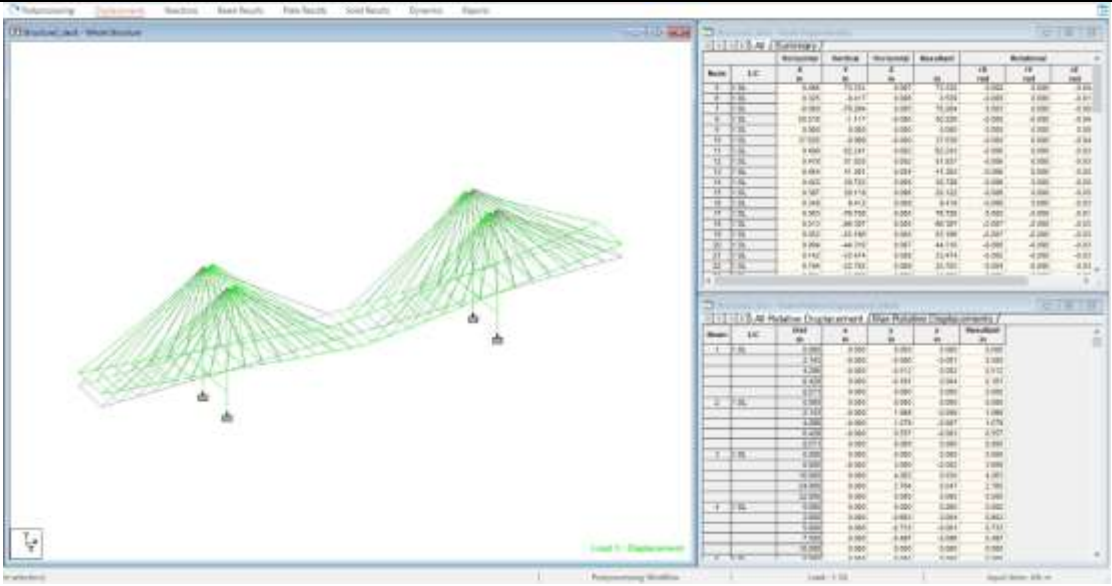


Fig 6 – Relative displacement of structure

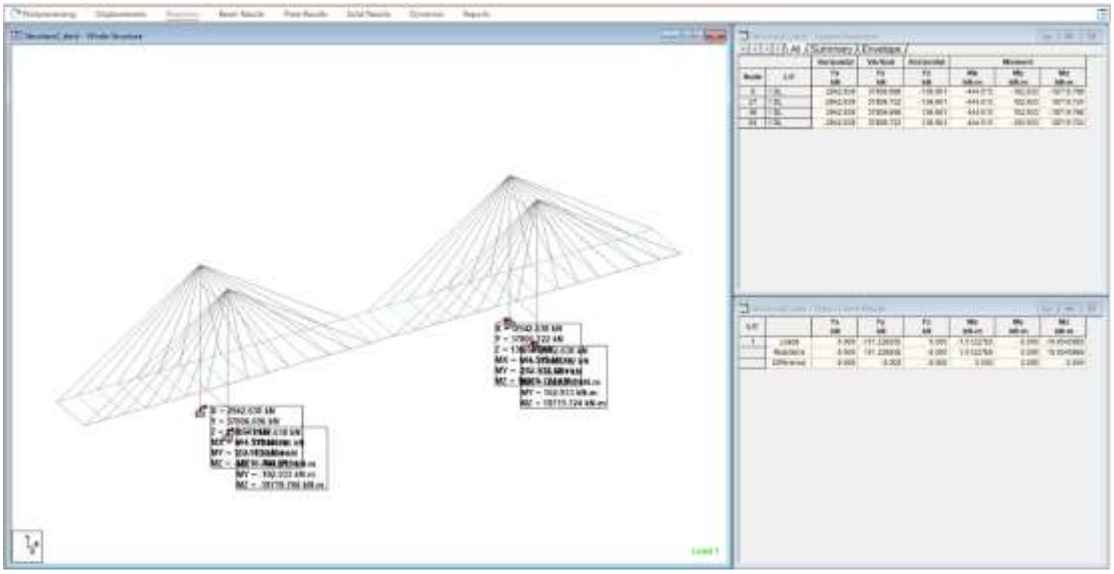


Fig 7 – Support reactions and moments developed due to statics

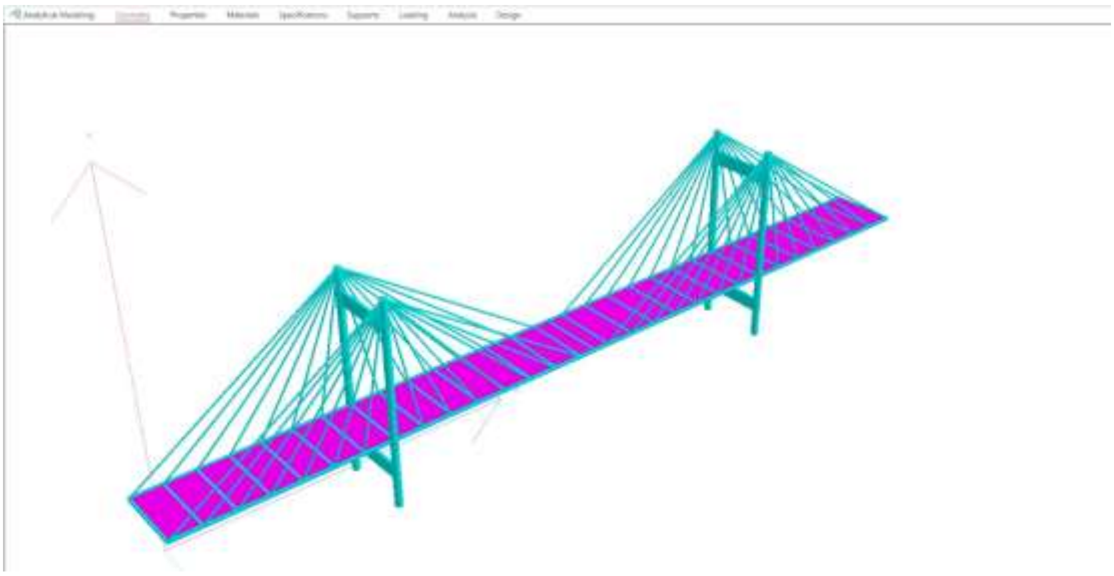


Fig 8 – Rendered view of model.

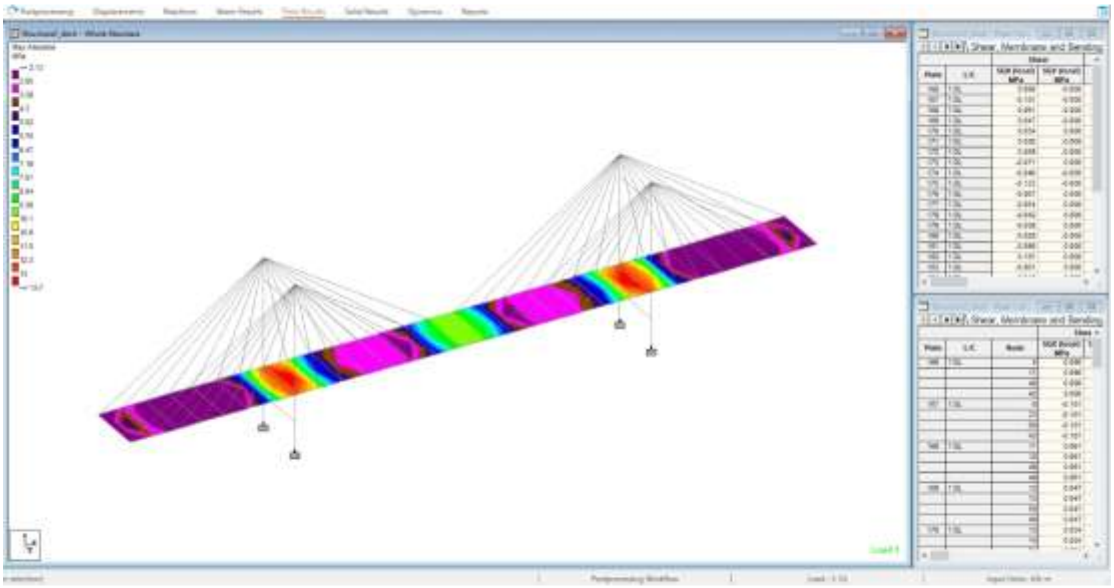


fig 9 – Plate results by shear and bending.

Report obtained by running analysis.

JOINT COORDINATES

8. 5 1 2 0; 6 61.0001 2 0; 7 126 2 0; 8 61.0001 42.0001 0;

9 61.0001 -18 0 9. 10 61.0001 34.0001 0; 11 9.57145 2 0; 12 18.1429 2 0; 13 26.7143 2 0

10. 14 35.2858 2 0; 15 43.8572 2 0; 16 52.4287 2 0; 17 121 2 0; 18 112.429 2 0

11. 19 103.857 2 0; 20 95.2859 2 0; 21 86.7145 2 0; 22 78.143 2 0; 23 69.5716 2 0

12. 24 251 2 0; 25 191 2 0; 26 191 42.0001 0; 27 191 -18 0; 28 191 34.0001 0

13. 29 242.429 2 0; 30 233.858 2 0; 31 225.286 2 0; 32 216.715 2 0; 33 208.143 2 0

14. 34 199.572 2 0; 35 131 2 0; 36 139.572 2 0; 37 148.143 2 0; 38 156.715 2 0

15. 39 165.286 2 0; 40 173.857 2 0; 41 182.429 2 0; 42 1 2 -20; 43 61.0001 2 -20

16. 44 126 2 -20; 45 61.0001 42.0001 -20; 46 61.0001 -18 -20

17. 47 61.0001 34.0001 -20; 48 9.57145 2 -20; 49 18.1429 2 -20; 50 26.7143 2 -20

18. 51 35.2858 2 -20; 52 43.8572 2 -20; 53 52.4287 2 -20; 54 121 2 -20

19. 55 112.429 2 -20; 56 103.857 2 -20; 57 95.2859 2 -20; 58 86.7145 2 -20

20. 59 78.143 2 -20; 60 69.5716 2 -20; 61 251 2 -20; 62 191 2 -20

21. 63 191 42.0001 -20; 64 191 -18 -20; 65 191 34.0001 -20; 66 242.429 2 -20

22. 67 233.858 2 -20; 68 225.286 2 -20; 69 216.715 2 -20; 70 208.143 2 -20

23. 71 199.572 2 -20; 72 131 2 -20; 73 139.572 2 -20; 74 148.143 2 -20

24. 75 156.715 2 -20; 76 165.286 2 -20; 77 173.857 2 -20; 78 182.429 2 -20

25. 79 61.0001 -8.00002 0; 80 191 -8.00002 0; 81 61.0001 -8.00002 -20

26. 82 191 -8.00002 -20

27. MEMBER INCIDENCES

28. 1 5 11; 2 6 23; 3 6 10; 4 6 79; 5 10 8; 6 11 12; 7 12 13; 8 13 14; 9 14 15

29. 10 15 16; 11 16 6; 12 5 8; 13 11 8; 14 12 8; 15 13 8; 16 14 8; 17 15 8

30. 18 16 8; 19 17 7; 20 18 17; 21 19 18; 22 20 19; 23 21 20; 24 22 21; 25 23 22

31. 26 17 8; 27 18 8; 28 19 8; 29 20 8; 30 21 8; 31 22 8; 32 23 8; 33 24 29

32. 34 25 41; 35 25 28; 36 25 80; 37 28 26; 38 29 30; 39 30 31; 40 31 32; 41 32 33

33. 42 33 34; 43 34 25; 44 24 26; 45 29 26; 46 30 26; 47 31 26; 48 32 26; 49 33 26

34. 50 34 26; 51 35 7; 52 36 35; 53 37 36; 54 38 37; 55 39 38; 56 40 39; 57 41 40

35. 58 35 26; 59 36 26; 60 37 26; 61 38 26; 62 39 26; 63 40 26; 64 41 26; 65 5 42

36. 66 6 43; 67 7 44; 70 10 47; 71 11 48; 72 12 49; 73 13 50; 74 14 51; 75 15 52

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49. 164 77 63; 165 78 63; 196 79 9; 197 80 27; 198 81 46; 199 82 64; 200 79 81

50. 201 82 80

51. ELEMENT INCIDENCES SHELL

52. 166 5 11 48 42; 167 6 23 60 43; 168 11 12 49 48; 169 12 13 50 49

53. 170 13 14 51 50; 171 14 15 52 51; 172 15 16 53 52; 173 16 6 43 53

54. 174 17 7 44 54; 175 18 17 54 55; 176 19 18 55 56; 177 20 19 56 57

55. 178 21 20 57 58; 179 22 21 58 59; 180 23 22 59 60; 181 24 29 66 61

56. 182 25 41 78 62; 183 29 30 67 66; 184 30 31 68 67; 185 31 32 69 68

57. 186 32 33 70 69; 187 33 34 71 70; 188 34 25 62 71; 189 35 7 44 72

58. 190 36 35 72 73; 191 37 36 73 74; 192 38 37 74 75; 193 39 38 75 76

59. 194 40 39 76 77; 195 41 40 77 78

60. ELEMENT PROPERTY

61. 166 TO 195 THICKNESS 0.3

62. DEFINE MATERIAL START

63. ISOTROPIC M

64. E 2.17185E+007

65. POISSON 0.17

66. DENSITY 23.5616

67. ALPHA 1E-005

68. DAMP 0.05

69. G 9.28139E+006

70. TYPE CONCRETE

71. STRENGTH FCU 60000

72. ISOTROPIC STEEL

73. E 1.99947E+008

74. POISSON 0.3

75. DENSITY 76.8191

76. ALPHA 6E-006

77. DAMP 0.03

78. TYPE STEEL

79. STRENGTH FY 248210 FU 399894 RY 1.5 RT 1.2

80. ISOTROPIC FE

81. E 2.05E+008

82. POISSON 0.3

83. DENSITY 76.8195

84. ALPHA 1.2E-005

85. DAMP 0.03

86. G 7.88462E+007

87. TYPE STEEL

88. STRENGTH FY 250000 FU 500000 RY 1.5 RT 1.2

89. END DEFINE MATERIAL

90. MEMBER PROPERTY AMERICAN

91. 3 TO 5 35 TO 37 104 TO 106 136 TO 138 196 TO 199 PRIS YD 2

92. 12 TO 18 26 TO 32 44 TO 50 58 TO 64 113 TO 119 127 TO 133 145 TO 151 _

93. 159 TO 165 PRIS YD 0.4

94. 70 88 200 201 PRIS YD 4 ZD 0.75

95. 1 2 6 TO 11 19 TO 25 33 34 38 TO 43 51 TO 57 65 TO 67 71 TO 85 89 TO 103 107 –

96. 108 TO 112 120 TO 126 134 135 139 TO 144 152 TO 158 PRIS YD 0.8 ZD 0.6 97. CONSTANTS

98. MATERIAL M MEMB 1 TO 11 19 TO 25 33 TO 43 51 TO 57 65 TO 67 70 TO 85 –

99. 88 TO 112 120 TO 126 134 TO 144 152 TO 158 166 TO 201

100. MATERIAL FE MEMB 12 TO 18 26 TO 32 44 TO 50 58 TO 64 113 TO 119 127 TO 133 –

101. 145 TO 151 159 TO 165

102. SUPPORTS

103. 9 27 46 64 FIXED

104. LOAD 1 LOADTYPE DEAD TITLE DL

105. SELFWEIGHT Y -1.5

106. PERFORM ANALYSIS PRINT ALL P R O B L E M S T A T I S T I C S

NUMBER OF JOINTS 78

NUMBER OF MEMBERS 167

NUMBER OF PLATES 30

NUMBER OF SOLIDS 0

NUMBER OF SURFACES 0

NUMBER OF SUPPORTS 4

SOLVER USED IS THE IN-CORE ADVANCED MATH SOLVER

TOTAL PRIMARY LOAD CASES = 1, TOTAL DEGREES OF FREEDOM = 444

1 LOADTYPE DEAD TITLE DL -----------

SELFWEIGHT Y -1.500

ACTUAL WEIGHT OF THE STRUCTURE = 100817.844 KN

FOR LOADING - 1

APPLIED JOINT EQUIVALENT LOADS JOINT

FORCE-X FORCE-Y FORCE-Z MOM-X MOM-Y MOM-Z

5 2.03972E-05-1.21884E+03 0.00000E+00-5.65478E+02 0.00000E+00-5.32477E+03 6 0.00000E+00-3.55553E+03 0.00000E+00-5.65478E+02 0.00000E+00-2.25501E-03 7 0.00000E+00-7.84600E+02 0.00000E+00-5.65478E+02 0.00000E+00-1.75849E-04 8 1.83048E-05-5.95455E+03 0.00000E+00 0.00000E+00 0.00000E+00 2.11295E-02 9 0.00000E+00-5.55156E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 10 0.00000E+00-3.28091E+03 0.00000E+00-3.53424E+03 0.00000E+00 0.00000E+00

11-2.67825E-06-1.69557E+03 0.00000E+00-5.65478E+02 0.00000E+00-4.04325E+03

12 5.34502E-06-1.64830E+03 0.00000E+00-5.65478E+02 0.00000E+00-3.03172E+03

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14 1.13069E-06-1.56814E+03 0.00000E+00-5.65478E+02 0.00000E+00-1.47550E+03

15 9.27967E-07-1.53894E+03 0.00000E+00-5.65478E+02 0.00000E+00-9.00231E+02

16-3.84587E-06-1.52004E+03 0.00000E+00-5.65478E+02 0.00000E+00-4.23107E+02

17 2.03766E-05-1.52629E+03 0.00000E+00-5.65478E+02 0.00000E+00 5.28939E+03

18-4.66727E-06-1.69558E+03 0.00000E+00-5.65478E+02 0.00000E+00 4.04331E+03

19-2.44263E-05-1.64831E+03 0.00000E+00-5.65478E+02 0.00000E+00 3.03167E+03

20 3.91057E-06-1.60526E+03 0.00000E+00-5.65478E+02 0.00000E+00 2.17961E+03

21 3.10623E-06-1.56814E+03 0.00000E+00-5.65478E+02 0.00000E+00 1.47551E+03

22 2.36704E-06-1.53894E+03 0.00000E+00-5.65478E+02 0.00000E+00 9.00226E+02

23-4.29065E-06-1.52004E+03 0.00000E+00-5.65478E+02 0.00000E+00 4.23117E+02

24-1.07958E-05-1.21881E+03 0.00000E+00-5.65478E+02 0.00000E+00 5.32474E+03

25 0.00000E+00-3.55553E+03 0.00000E+00-5.65478E+02 0.00000E+00-2.43499E-02

26-8.21126E-06-5.95455E+03 0.00000E+00 0.00000E+00 0.00000E+00-4.52629E-01

27 0.00000E+00-5.55156E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00

28 0.00000E+00-3.28091E+03 0.00000E+00-3.53424E+03 0.00000E+00 0.00000E+00

29 4.11628E-06-1.69552E+03 0.00000E+00-5.65478E+02 0.00000E+00 4.04330E+03

30 2.72510E-05-1.64831E+03 0.00000E+00-5.65478E+02 0.00000E+00 3.03183E+03

31-2.24513E-05-1.60530E+03 0.00000E+00-5.65478E+02 0.00000E+00 2.17960E+03

32-1.10190E-05-1.56815E+03 0.00000E+00-5.65478E+02 0.00000E+00 1.47558E+03

33 2.05420E-06-1.53894E+03 0.00000E+00-5.65478E+02 0.00000E+00 9.00210E+02

34-4.92034E-06-1.52004E+03 0.00000E+00-5.65478E+02 0.00000E+00 4.23165E+02

35 1.07958E-05-1.52635E+03 0.00000E+00-5.65478E+02 0.00000E+00-5.28943E+03

36 2.47177E-06-1.69558E+03 0.00000E+00-5.65478E+02 0.00000E+00-4.04315E+03

37 4.88044E-06-1.64831E+03 0.00000E+00-5.65478E+02 0.00000E+00-3.03172E+03

38 1.07216E-06-1.60529E+03 0.00000E+00-5.65478E+02 0.00000E+00-2.17951E+03

39-1.25804E-05-1.56809E+03 0.00000E+00-5.65478E+02 0.00000E+00-1.47548E+03

40-2.05420E-06-1.53894E+03 0.00000E+00-5.65478E+02 0.00000E+00-9.00259E+02

41 2.96813E-06-1.52004E+03 0.00000E+00-5.65478E+02 0.00000E+00-4.23065E+02

42 2.03972E-05-1.21884E+03 0.00000E+00 5.65478E+02 0.00000E+00-5.32477E+03

43 0.00000E+00-3.55553E+03 0.00000E+00 5.65478E+02 0.00000E+00-2.25501E-03

44 0.00000E+00-7.84600E+02 0.00000E+00 5.65478E+02 0.00000E+00-1.75849E-04

45 1.83048E-05-5.95455E+03 0.00000E+00 0.00000E+00 0.00000E+00 2.11295E-02 46 0.00000E+00-5.55156E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00

47 0.00000E+00-3.28091E+03 0.00000E+00 3.53424E+03 0.00000E+00 0.00000E+00

48-2.67825E-06-1.69557E+03 0.00000E+00 5.65478E+02 0.00000E+00-4.04325E+03

49 5.34502E-06-1.64830E+03 0.00000E+00 5.65478E+02 0.00000E+00-3.03172E+03

50 6.51762E-07-1.60529E+03 0.00000E+00 5.65478E+02 0.00000E+00-2.17961E+03

51 1.13069E-06-1.56814E+03 0.00000E+00 5.65478E+02 0.00000E+00-1.47550E+03

52 9.27967E-07-1.53894E+03 0.00000E+00 5.65478E+02 0.00000E+00-9.00231E+02

53-3.84587E-06-1.52004E+03 0.00000E+00 5.65478E+02 0.00000E+00-4.23107E+02

54 2.03766E-05-1.52629E+03 0.00000E+00 5.65478E+02 0.00000E+00 5.28939E+03 55-4.66727E-06-1.69558E+03 0.00000E+00 5.65478E+02 0.00000E+00 4.04331E+03

56-2.44263E-05-1.64831E+03 0.00000E+00 5.65478E+02 0.00000E+00 3.03167E+03

57 3.91057E-06-1.60526E+03 0.00000E+00 5.65478E+02 0.00000E+00 2.17961E+03 58 3.10623E-06-1.56814E+03 0.00000E+00 5.65478E+02 0.00000E+00 1.47551E+03 59 2.36704E-06-1.53894E+03 0.00000E+00 5.65478E+02 0.00000E+00 9.00226E+02 60-4.29065E-06-1.52004E+03 0.00000E+00 5.65478E+02 0.00000E+00 4.23117E+02

61-1.07958E-05-1.21881E+03 0.00000E+00 5.65478E+02 0.00000E+00 5.32474E+03

62 0.00000E+00-3.55553E+03 0.00000E+00 5.65478E+02 0.00000E+00-2.43499E-02

63-8.21126E-06-5.95455E+03 0.00000E+00 0.00000E+00 0.00000E+00-4.52629E-01

64 0.00000E+00-5.55156E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00

65 0.00000E+00-3.28091E+03 0.00000E+00 3.53424E+03 0.00000E+00 0.00000E+00

66 4.11628E-06-1.69552E+03 0.00000E+00 5.65478E+02 0.00000E+00 4.04330E+03 67 2.72510E-05-1.64831E+03 0.00000E+00 5.65478E+02 0.00000E+00 3.03183E+03 68-2.24513E-05-1.60530E+03 0.00000E+00 5.65478E+02 0.00000E+00 2.17960E+03

69-1.10190E-05-1.56815E+03 0.00000E+00 5.65478E+02 0.00000E+00 1.47558E+03

70 2.05420E-06-1.53894E+03 0.00000E+00 5.65478E+02 0.00000E+00 9.00210E+02 71-4.92034E-06-1.52004E+03 0.00000E+00 5.65478E+02 0.00000E+00 4.23165E+02

72 1.07958E-05-1.52635E+03 0.00000E+00 5.65478E+02 0.00000E+00-5.28943E+03

73 2.47177E-06-1.69558E+03 0.00000E+00 5.65478E+02 0.00000E+00-4.04315E+03

74 4.88044E-06-1.64831E+03 0.00000E+00 5.65478E+02 0.00000E+00-3.03172E+03

75 1.07216E-06-1.60529E+03 0.00000E+00 5.65478E+02 0.00000E+00-2.17951E+03

76-1.25804E-05-1.56809E+03 0.00000E+00 5.65478E+02 0.00000E+00-1.47548E+03

77-2.05420E-06-1.53894E+03 0.00000E+00 5.65478E+02 0.00000E+00-9.00259E+02

78 2.96813E-06-1.52004E+03 0.00000E+00 5.65478E+02 0.00000E+00-4.23065E+02

79 0.00000E+00-2.17059E+03 0.00000E+00-3.53424E+03 0.00000E+00 0.00000E+00

80 0.00000E+00-2.17059E+03 0.00000E+00-3.53424E+03 0.00000E+00 0.00000E+00

81 0.00000E+00-2.17059E+03 0.00000E+00 3.53424E+03 0.00000E+00 0.00000E+00

82 0.00000E+00-2.17059E+03 0.00000E+00 3.53424E+03 0.00000E+00 0.00000E+00

STATIC LOAD/REACTION/EQUILIBRIUM SUMMARY FOR CASE NO. 1 LOADTYPE DEAD

TITLE DL CENTER OF FORCE BASED ON Y FORCES ONLY (METE). (FORCES IN NON-GLOBAL DIRECTIONS WILL INVALIDATE RESULTS)

X = 0.126000077E+03

Y = 0.102092014E+02

Z = -0.100000003E+02

***TOTAL APPLIED LOAD (KN METE)

SUMMARY (LOADING 1)

SUMMATION FORCE-X = 0.00

SUMMATION FORCE-Y = -151226.84

SUMMATION FORCE-Z = 0.00

SUMMATION OF MOMENTS AROUND THE ORIGIN-

MX= -1512268.40

MY= -0.00

MZ= -19054592.98

***TOTAL REACTION LOAD (KN METER) SUMMARY (LOADING 1) SUMMATION FORCE-X = -0.00

SUMMATION FORCE-Y = 151226.84

SUMMATION FORCE-Z = 0.00

SUMMATION OF MOMENTS AROUND THE ORIGIN-

MX= 1512268.40

MY= 0.00

MZ= 19054593.19

MAXIMUM DISPLACEMENTS (CM /RADIANS) (LOADING 1)

MAXIMUMS AT NODE

X = 1.27549E+02 8

Y = -1.98842E+02 7

Z = -2.16222E-01 26

RX= 8.30574E-03 53

RY= -1.55996E-04 25

RZ= -4.51877E-02 5

EXTERNAL AND INTERNAL JOINT LOAD SUMMARY (KN METE)-

JT EXT FX/ EXT FY/ EXT FZ/ EXT MX/ EXT MY/ EXT MZ/

INT FX INT FY INT FZ INT MX INT MY INT MZ

SUPPORT=1

9 0.00 -555.16 0.00 0.00 0.00 0.00 -2942.64 -37251.54 136.60 444.51 102.93 18719.76 111111

27 0.00 -555.16 0.00 0.00 0.00 0.00 2942.64 -37251.57 136.60 444.51 -102.93 -18719.72 111111

46 0.00 -555.16 0.00 0.00 0.00 0.00 -2942.64 -37251.54 -136.60 -444.51 -102.93 18719.76 111111

64 0.00 -555.16 0.00 0.00 0.00 0.00 2942.64 -37251.57 -136.60 -444.51 102.93 -18719.72 111111

************ END OF DATA FROM INTERNAL STORAGE ************

107. PERFORM ANALYSIS PRINT ALL

IV. RESULTS AND DISCUSSION

1. IN THIS ANALYSIS AND DESIGN OF CABLE STAYED BRIDGE STRUCTURE, FAN SYSTEM CABLE STAYED BRIDGE WAS DESIGNED AND ANALYSED USING STAAD PRO SOFTWARE.
2. DETAILED STEP WISE PROCEDURE WAS DISCUSSED INCLUDING HOW TO CREATE MODEL OF BRIDGE, GIVING MATERIAL SPECIFICATIONS, GIVING LOADING CONDITIONS.
3. ACTUAL WEIGHT OF THE STRUCTURE = 100817.844 KN

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